Validation of RadCalNet at RVUS and LCFR using MISR data

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RadCalNet telecon
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MISR

- Terra spacecraft (with MODIS)
- 9 cameras at range of view angles, "An" camera is nadir-viewing
- An spatial resolution: 275 m
- Spectral Bands

Band	1	2	3	4
Wav ctr, nm	446.4	557.5	671.7	866.4
wav width, nm	41.9	28.6	21.9	39.7
Eo, W m-2 um-1	1871.	1851.	1525.	969.8

- L1B2 product reports TOA radiance with BRF correction factor

$$\rho\_toa = \frac{\pi \cdot L \cdot d^2}{E_o \cdot \cos(\theta_{sun})} = BRF\_conversionFactor \cdot L$$

MISR, cont.

- Observes mid-latitude sites on 3 paths every 16 days

	RVUS		LCFR	
View	Path	View zenith	Path	View zenith
from W	39	~11º	195	~11º
nadir	40	<1.0º	196	<1.5º
from E	41	~-10º	197	~-9º

- Initial absolute calibration established via year 2000 Vicarious Calibration campaign at Lunar Lake, NV. Radiative transfer code was a line-by-line code, not accounting for water vapor.
- Calibration maintained by bi-monthly on-board calibrator views
- Small corrections to trend determined via Sahara Desert views
- Ghost correction algorithm has developed
- Data will be reprocessed end of mission, to implement Ghost correction, Sahara trend analysis, and inclusion of water vapor in RTC

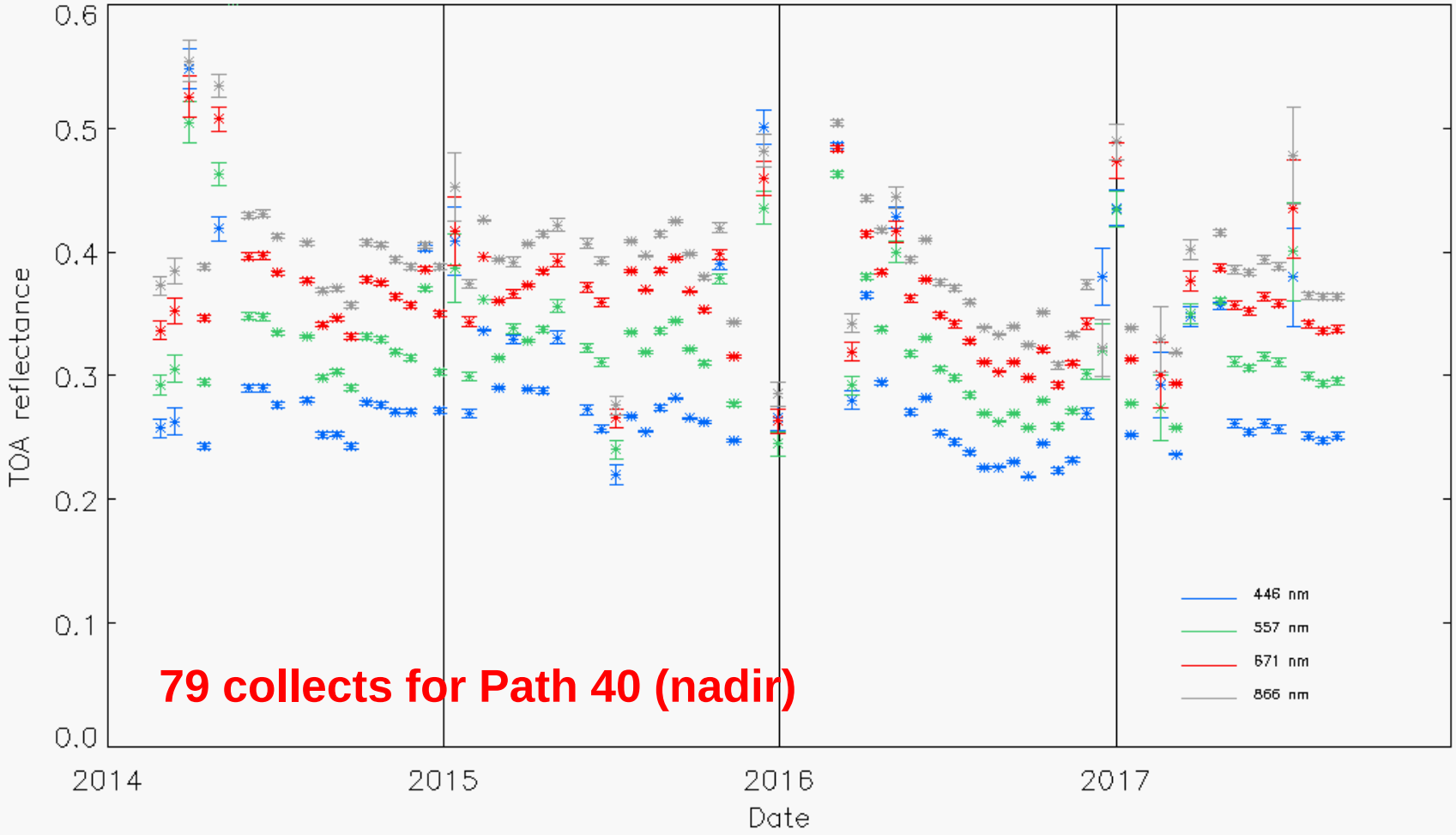
MISR data extraction

- Railroad Valley (RVUS), La Crau (LCFR) MISR data extracted
  - Baotou site not investigated due to target size

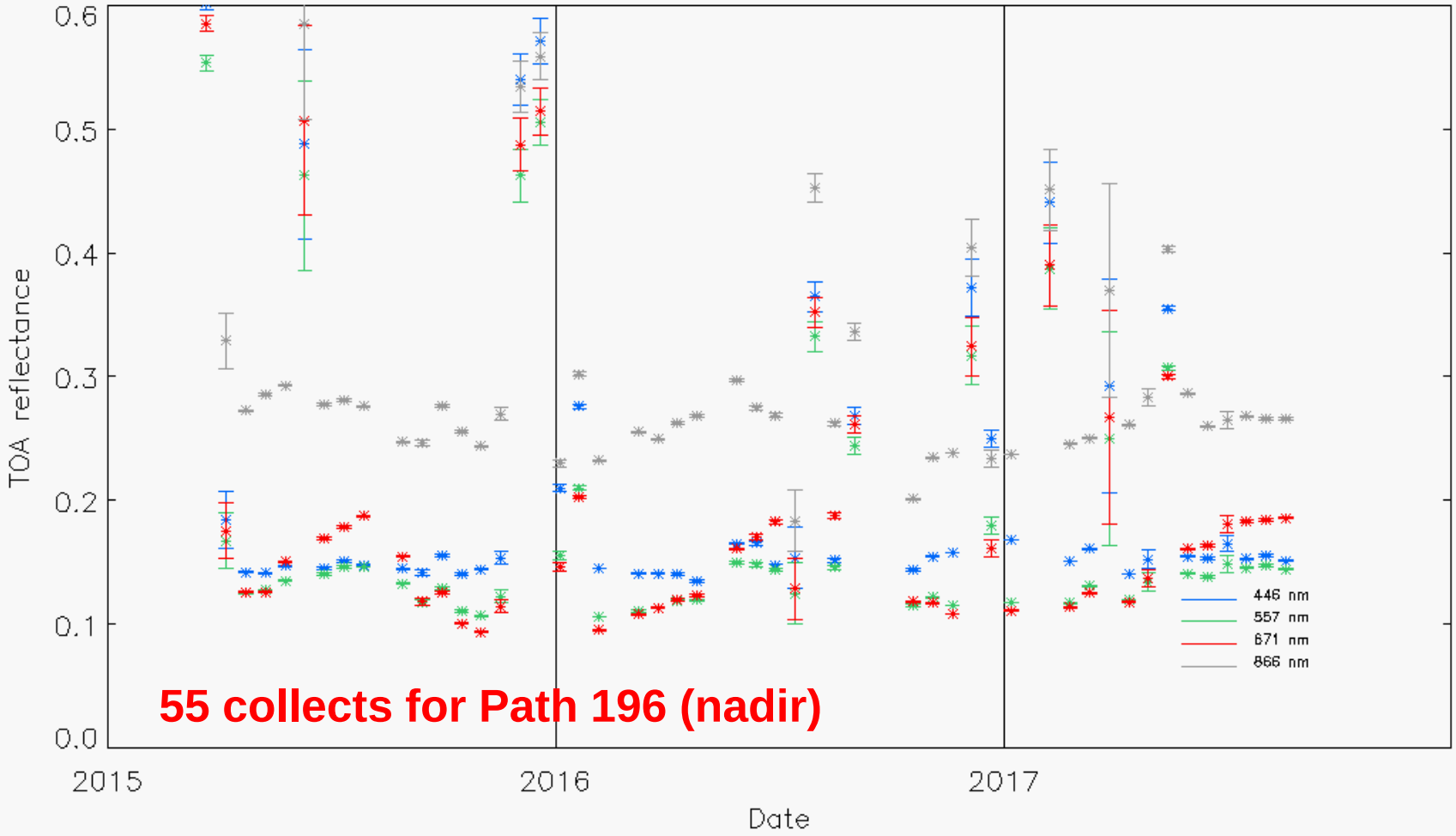
- MISR radiances extracted from nadir paths only dates
  - 18 matchups at RVUS
  - 14 matchups at LCFR
  - Took closest pixel (275 m)
  - Computed mean and stdev of 3x3
  - Interpolated RadCalNet (RCN) to 1 nm sampling
  - Used MISR eq. squareband for band integration

- Error propagation
  - ε_misr=mean(σ_3x3 pixels)
  - ε_rcn =mean error from daily RCN download
  - ε_ratio/ mean_ratio = ε_misr/ρ_misr + ε_rcn/ρ_rcn

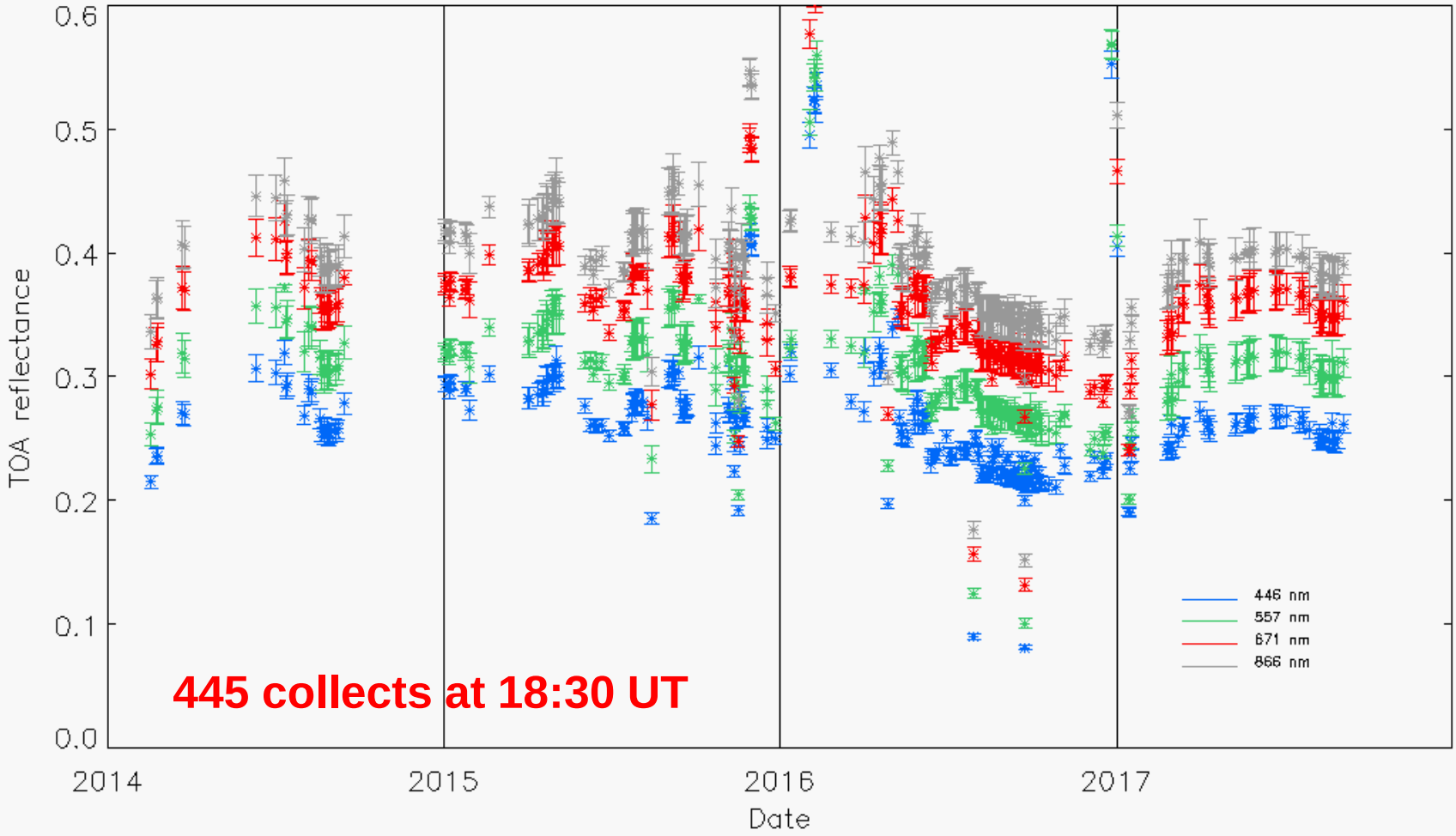
MISR TOA refl over Railroad Valley



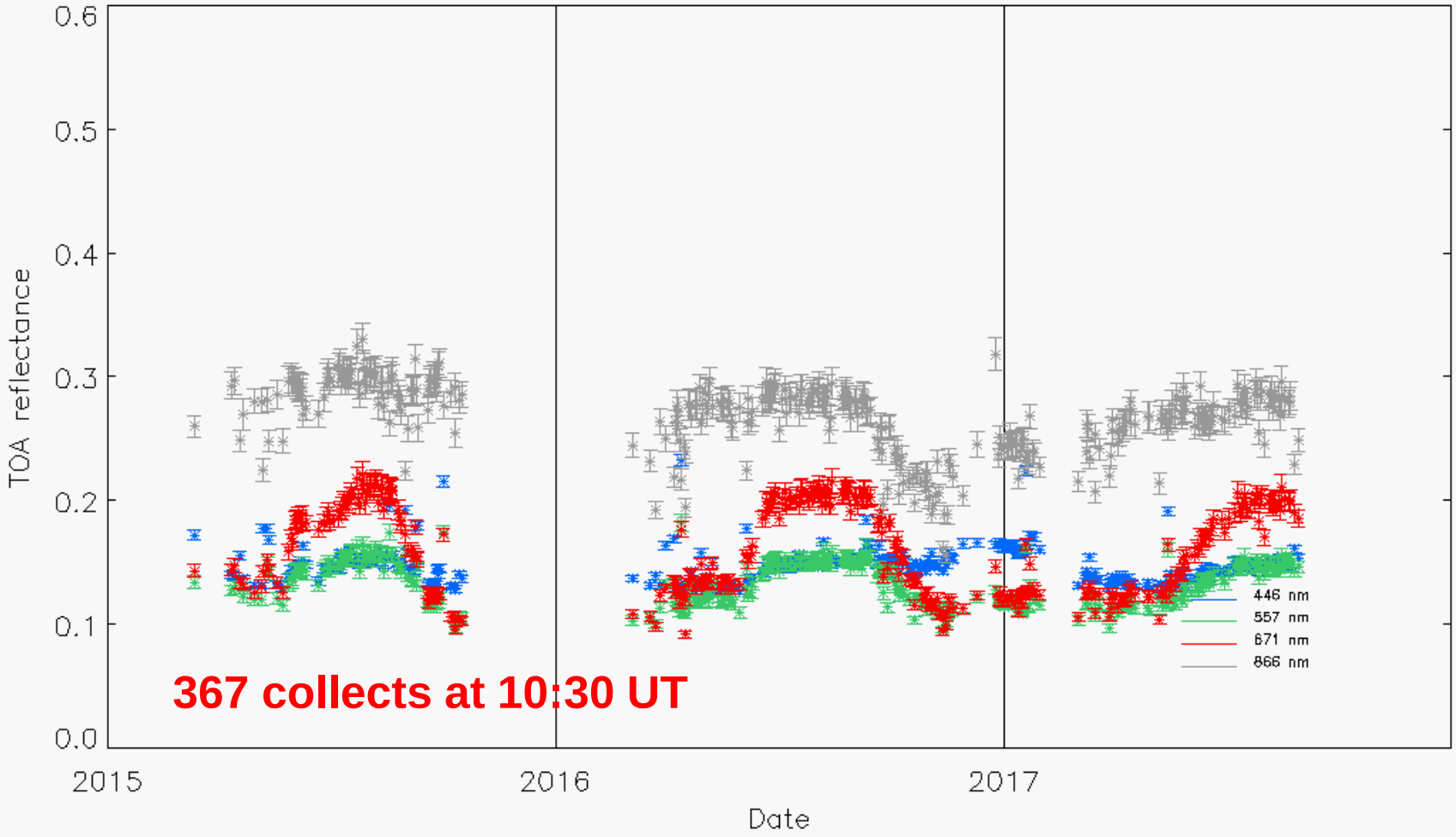
MISR TOA refl over La Crau



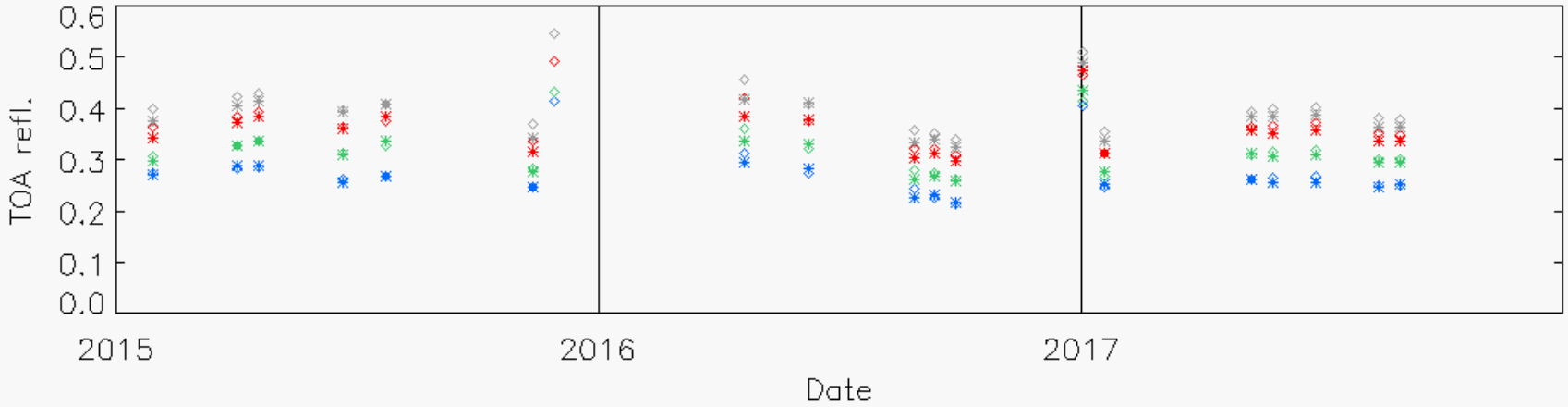
RVUS TOA refl

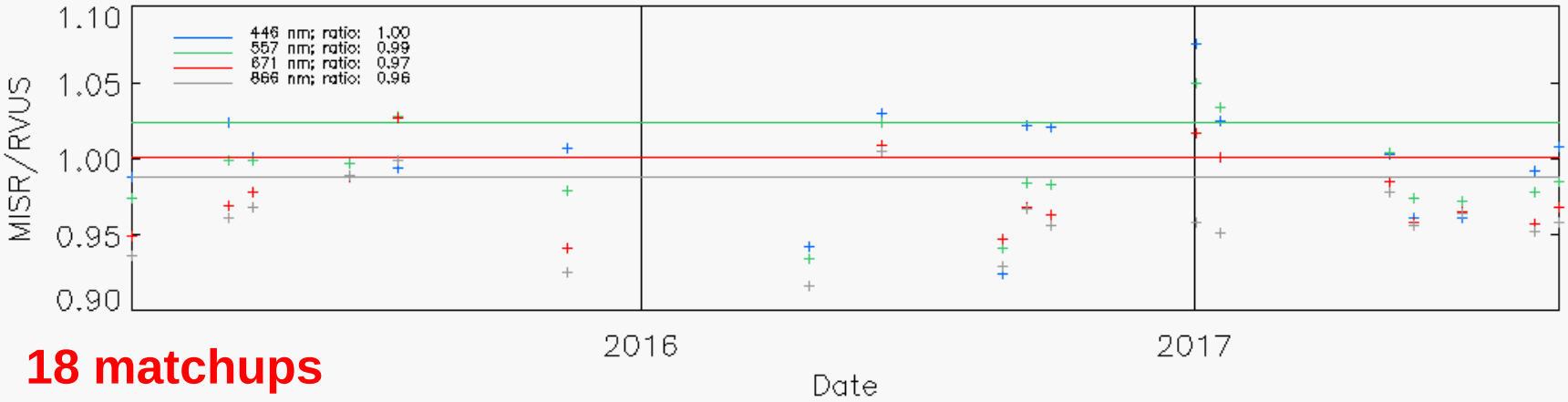


LCFR TOA refl



Ratio MISR/ RVUS

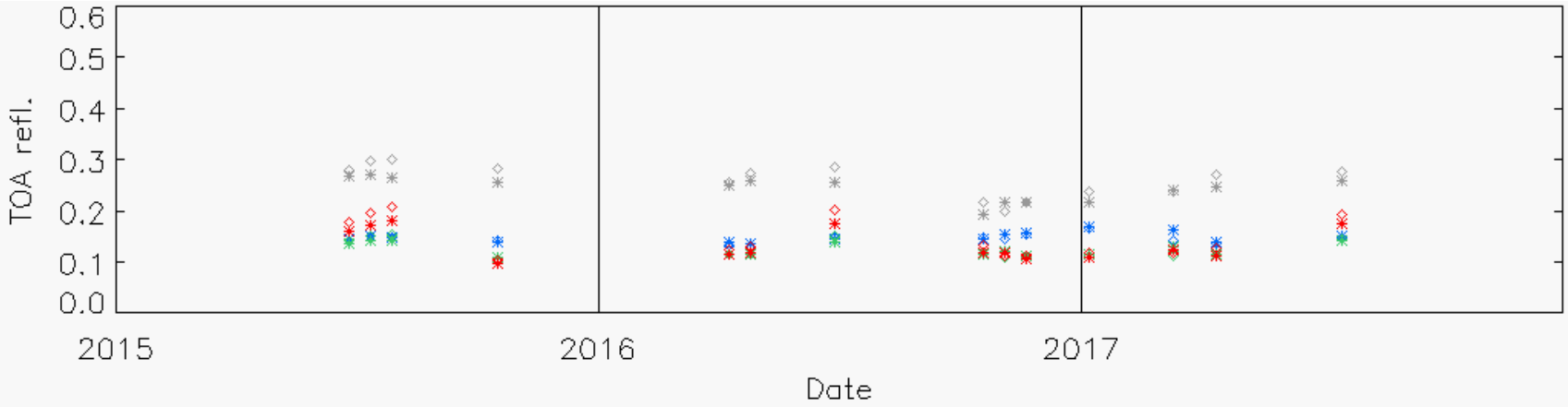


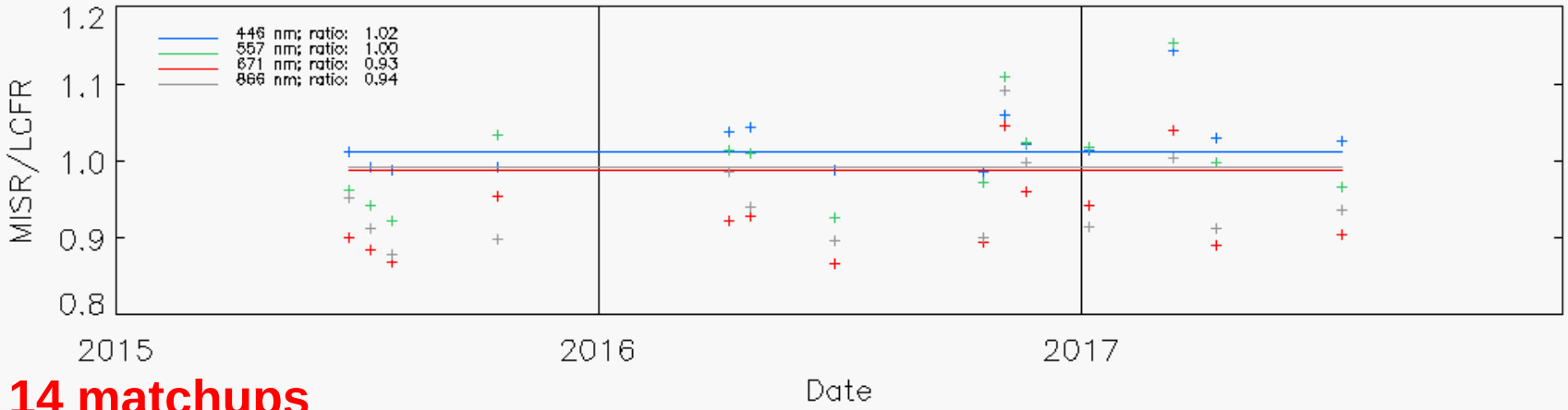


18 matchups

28Nov2017 ratio was >1.6, and was removed from trend

Ratio MISR/ LCFR





14 matchups

27Mar2017 ratio was >3; 28Apr2017 ratio was > 1.2. Both removed from trend

Results

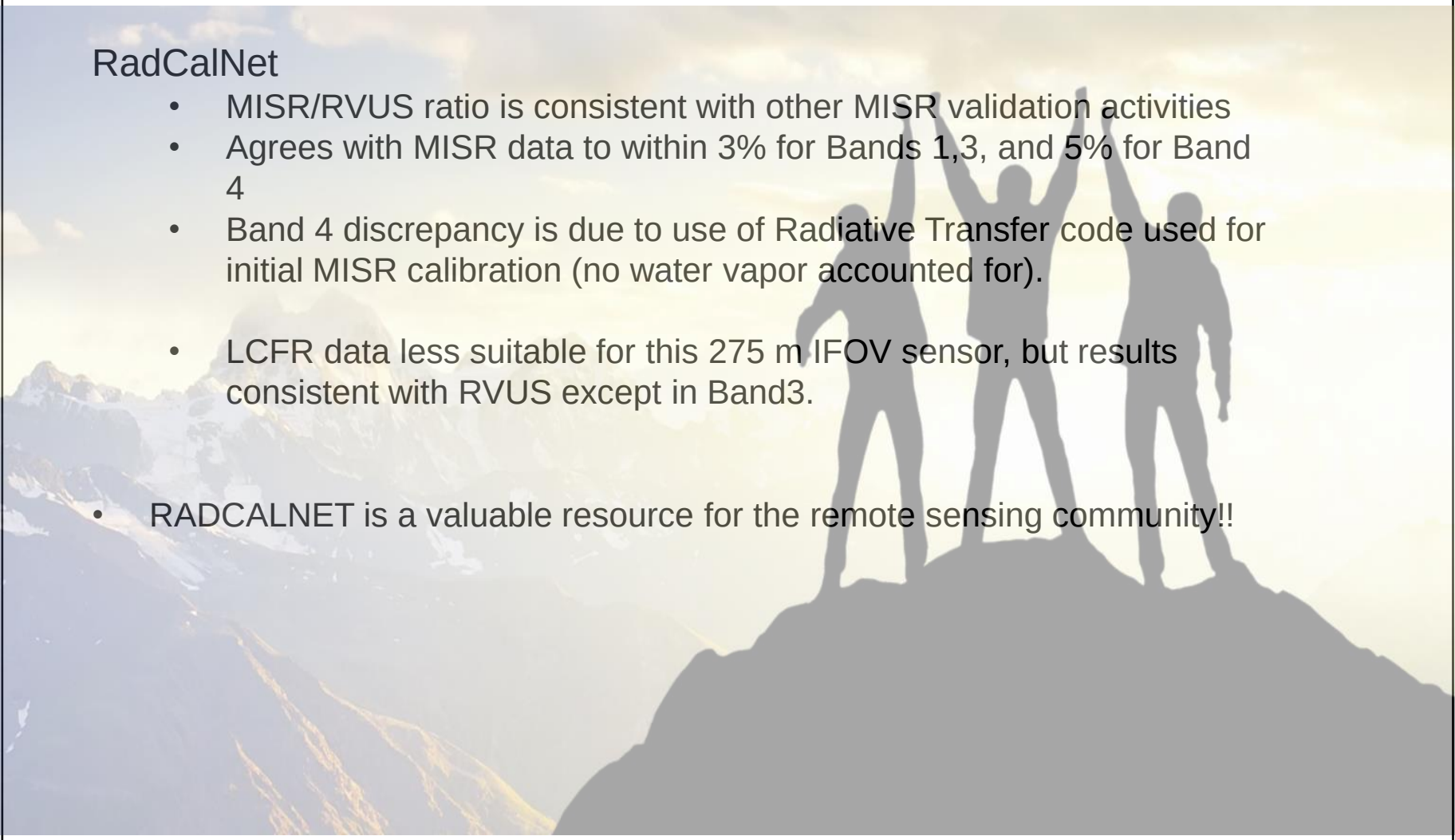
- RVUS

Wav ctr, nm	446.4	557.5	671.7	866.4
median MISR/RVUS	1.002	0.985	0.968	0.958
mean MISR/RVUS	0.998	0.991	0.972	0.956
ε_ratio/ mean_ratio	0.037	0.043	0.041	0.042

- LCFR

Wav ctr, nm	446.4	557.5	671.7	866.4
median MISR/LCFR	1.021	1.009	0.922	0.936
mean MISR/LCFR	1.023	1.003	0.928	0.944
ε_ratio/ mean_ratio	0.024	0.054	0.063	0.089

Success!!



RadCalNet

- MISR/RVUS ratio is consistent with other MISR validation activities
- Agrees with MISR data to within 3% for Bands 1,3, and 5% for Band 4
- Band 4 discrepancy is due to use of Radiative Transfer code used for initial MISR calibration (no water vapor accounted for).
- LCFR data less suitable for this 275 m IFOV sensor, but results consistent with RVUS except in Band3.

- RADCALNET is a valuable resource for the remote sensing community!!

Feedback

Mistakes I made

- DOWNLOAD: Downloaded hundreds of RCN files manually, day by day. Failed to notice home page link.
- SUGGEST: Put "download all from this site" link on all monthly download calendar pages.

- TOA: Spent a day computing TOA reflectance ignoring earth-sun distance. This was based on RCN documentation (see backup slide). At telecon realized this was unnecessary, as MISR TOA refl. can be extracted directly from the L1B data product.
- SUGGEST: reword the RadCalNet_File_Specs_v*.pdf document

- PASSWORD: Two weeks before the telecon I lost access to data, since the password I wrote down was in error. 10 days later I resolved the issue myself, when I found a year-old email in my in-box.
- SUGGEST: If user requests, reset password by next business day

Feedback, cont.

Solar irradiance model, Eo

- RVUS documents should provide reference to the Eo used to compute BOA reflectance from the automated sensor data
- RCN should have a link to the RVUS Eo
- RCN should have a means to identify and let user select RVUS field data, which is presumably more accurate that the automated sensor data
- RCN documents should include a discussion of how to compare sensor TOA radiances to RCN TOA reflectances

Ephemeris data

- TOA reflectance has a strong dependence on solar view and azimuth (see backup slide).
- SUGGEST: Include ephemeris data in output files (solar view, azimuth, and earth-sun distance

JPL VicCal experience

- MISR absolute calibration established by vicarious calibration at Lunar Lake, year 2000

- OCO2 conducts mega-campaign each June 21st, starting in 2009
  - PARABOLA off-nadir scanner
  - "Mini-campaign" each spring/ fall. No PARABOLA data
  - OCO2 VicCal processing algorithm uses MODIS surface BRF to adjust in-situ BOA for off-nadir view angles

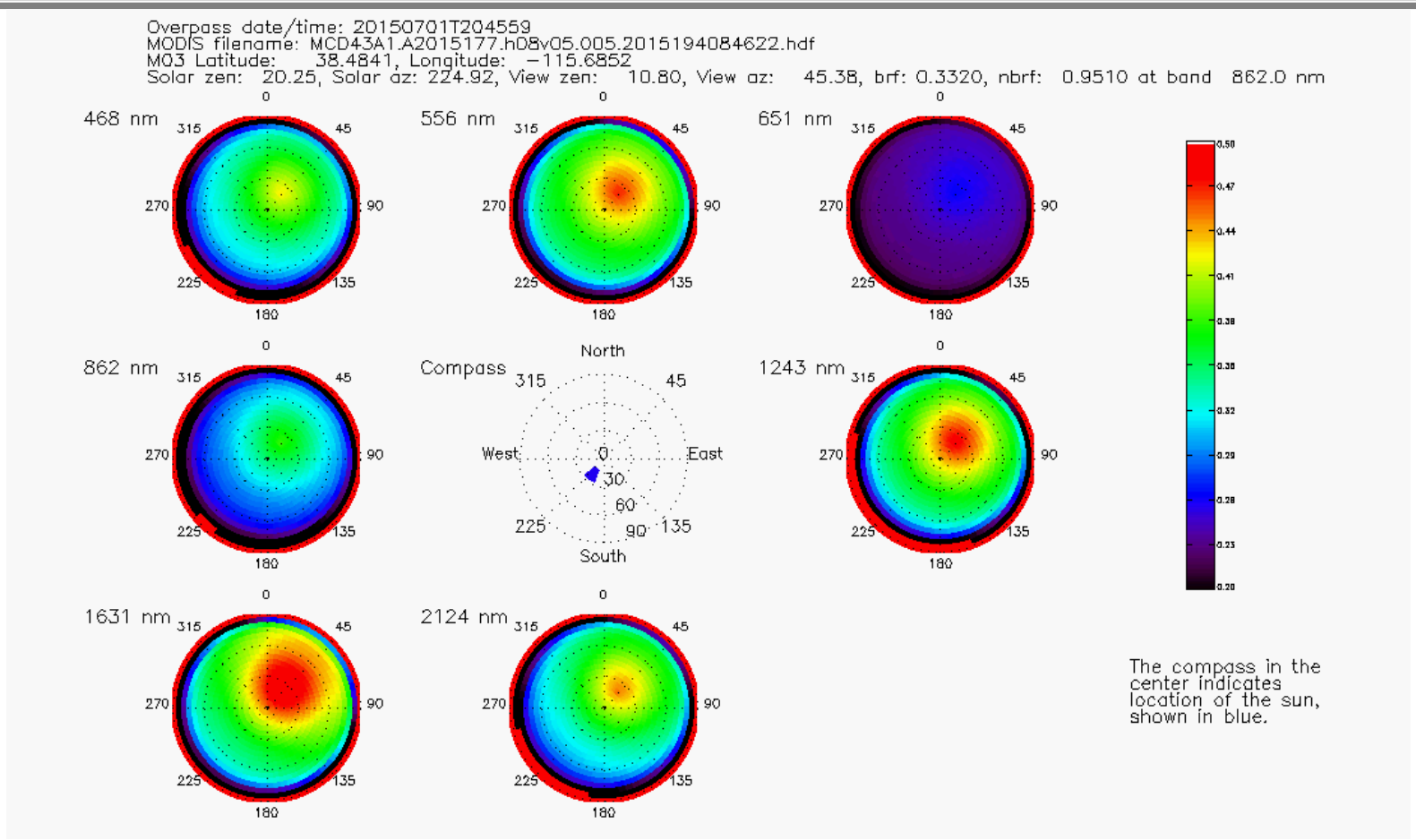
- In-situ field data from 2011
  - BOA reflectance 350-2500 nm
  - 28 sensors at 4 sites
  - on-site meteorological data

Future work (for March 2018)

- Continue validation of RVUS by comparison of BOA reflectance with JPL field data
- Report on use of RVUS for OCO-2 calibration, using off-nadir correction
- Make off-nadir correction: model based on PARABOLA or measured MODIS BRF

BACKUP SLIDES

MODIS BRF data product at OCO overpass time (1330 PDT)



BRF is a strong function of view and solar geometry, even with near nadir looks!!

RadCalNet TOA refl

I incorrectly assumed TOA_sun was the solar irradiance model, and thus RCN data did not include an earth-sun correction, d, and therefore I had to extract MISR data removing d^2. Yes, I understand d^2 is required in the conversion between TOA radiance and TOA refl, however I have noted in the past various sensors defining TOA refl. differently.

Please clarify your document using d^2/Eo instead of TOA_sun

RadCalNet_File_Specs_v7.pdf

4.0 Data Processing
TOA_refl = (TOA_rad * ρ) / (TOA_sun * cos(θ))

MODIS TOA reflectance (L1B)

- MODIS Level 1B Product User's Guide, MCST #PUB-01-U-0202-RevC, 27Feb2009

$$L = \frac{E_o \cdot \rho\_modis\_toa}{\pi \cdot d^2}$$ Eqn 5.7

and therefore $$\rho\_modis\_toa = \frac{\pi \cdot L \cdot d^2}{E_o}$$

Different sensors define TOA refl different than expected

comparing this to MISR's equivalent reflectance, we see that MODIS TOA (top-of-atmosphere) reflectance has been adjusted for earth-sun distance but not sun illumination. We see the following:

$$\rho\_toa = \frac{\pi \cdot L \cdot d^2}{E_o \cdot \cos(\theta_{sun})} = \frac{\rho\_modis\_toa}{\cos(\theta_{sun})} = \frac{\rho\_misr\_equiv \cdot d^2}{\cos(\theta_{sun})}$$

$$\rho\_misr\_equiv = \frac{\pi \cdot L}{E_o} = \rho\_modis\_toa / d^2$$